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ABSTRACT

With videodisc still two to five years away from adoption in mainstream schools, it is now time to step back and assess how this new media can best serve teachers and learners. This assessment begins with informal profiles of videodisc use patterns in a variety of school classrooms and analyses of the key factors underlying these early and often experimental uses. This study shows two interconnected variables at work when schools use videodisc: those related to the disc itself and those related to the classroom or school environment. The design approach embedded in a videodisc influences how adaptable a disc is to a variety of classroom purposes. The ways teachers and students use videodisc is influenced by three major factors: the teaching and learning activity undertaken; the degree of access to videodisc equipment; and school-wide attitudes toward teaching with technology. It is concluded that videodisc can promote understanding through active inquiry when it offers flexible and open-ended design and opportunities for teachers and students to choose, explore, and manipulate videodisc images. Based on variables related to both videodisc design and educational context, ways for secondary school teachers and students to take best advantage of what is uniquely useful about videodisc technology are suggested. (16 references) (Author/EW)

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EDUCATIONAL VIDEODISCS: THE INFLUENCE OF DESIGN APPROACHES AND SCHOOL FACTORS ON EARLY CLASSROOM USES

Technical Report

June 1988

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Educational Videodiscs: The Influence of Design Approaches and School Factors on Early Classroom Uses

Technical Report
June 1988

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Table of Contents

Abstract

1. Introduction....1

2. Educational Videodisc....3

Definition of the videodisc medium....3
Educational videodisc design approaches....5

3. Case Studies of Early Videodisc Use in Classrooms....8

4. Discussion: Variables Influencing Early Videodisc Use in Classrooms....20

Videodisc design approaches and their effect on disc use....20
Educational context and its effect on disc use....25

5. Conclusions....30

Trends revealed by case studies....30
Suggested classroom use strategies....35
Designing for the future....37

6. References....39

Abstract

With videodisc still two to five years away from adoption in mainstream schools, we believe now is the time to step back and assess how this new media can best serve teachers and learners. We begin this assessment by informally profiling videodisc use patterns in a variety of school classrooms and analyzing the key factors underlying these early and often experimental uses. Our study shows two interconnected variables at work when schools use videodisc--those related to the disc itself and those related to the classroom or school environment. The design approach embedded in a videodisc influences how adaptable a disc is to a variety of classroom purposes. The ways teachers and students use videodisc is influenced by three major factors: the teaching and learning activity undertaken; the degree of access to videodisc equipment; and school-wide attitudes toward teaching with technology. We conclude that videodisc can promote understanding through active inquiry when it offers flexible and open-ended design and opportunities for teachers and students to choose, explore, and manipulate videodisc images. Considering variables related to both videodisc design and educational context, we suggest ways for secondary school teachers and students to take best advantage of what is uniquely useful about videodisc technology.

1. Introduction

Like television and microcomputers before it, videodisc is heralded as a revolutionary educational technology--one that offers the best features of other media combined. While some industry observers liken videodisc to Gutenberg's printing press as a milestone in information technology, educational researchers and practitioners see it primarily as a visual medium with great promise for instructional use.

It is clear that videodisc's ability to store and randomly retrieve vast amounts of high-quality visual data presents intriguing new teaching and learning opportunities. A variety of research centers nationwide (Bank Street College, Educational Development Center, and the Harvard Educational Technology Center), a few major corporations (Apple and RCA), and a variety of funding agencies (National Science Foundation and Office of Educational Research and Improvement), are devoting resources to the development and exploration of educational videodisc materials. And not surprisingly, teachers and administrators are showing increasing interest in the adoption and implementation of the technology in schools. Some schools are already experimenting with commercially available players and discs.

With videodisc and even newer multimedia technology (e.g., Digital Video Interactive--DVI) still two to five years away from adoption in mainstream schools, we believe now is the time to step back and assess what these new media might mean for teachers and learners. This paper reflects on four years of research on educational videodiscs conducted by the WGBH Educational Foundation; the paper is a Harvard Educational Technology Center project. As part of this research, we designed and produced a prototype interactive videodisc, "Seeing the Unseen," and studied the use of this videodisc in middle school science classrooms (Storey, Lasker, & Janszen, 1985; Storey, Vasington, & Mellin, 1987).

Our research indicated that overall, students and teachers were enthusiastic about using "Seeing the Unseen"; they liked the compelling visual images and interactivity. However, we realized that its structured design approach limited users' ability to control

the learning experience. Students working individually or in pairs found they could choose different options and control the pace of their interactions, but their movement through disc content was mostly linear and predetermined by built-in instructional designs. Among classroom groups, the videodisc served largely as a presentation tool managed by the teacher, further restricting individual interactions and control.

These findings led us to ask questions about how different videodisc design approaches influence teaching and learning, and about how school factors influence videodisc use. We began to wonder what will happen when videodisc technology becomes more widely available and teachers begin experimenting with it in their classrooms. What factors will influence how teachers and students use videodisc technology? How can teachers and students most effectively use videodisc in the classroom?

This paper examines the nature of videodisc technology and educational design approaches, and presents case studies of early experimentation with videodisc in secondary schools. We discuss how videodisc design, in combination with school factors, such as teaching and learning activities, access to equipment, and school culture, affect how videodisc is used in classrooms. Finally, we suggest ways for secondary school teachers to take best advantage of what is uniquely useful about the technology.

2. Educational Videodisc

It is important to understand the nature of the videodisc medium before discussing its potential roles in education. In this section of the report, we define videodisc and describe its universal qualities, and then examine the types of educational discs created for the technology.

Definition of the videodisc medium.

Interactive videodisc is difficult to define with precision. A wide variety of vague adjectives are used to describe the technology, including visual, nonlinear, user-controlled, and convenient. These adjectives may have significance to the already initiated, but they do little to enlighten educators who need hard facts and meaningful interpretations of what videodisc is and what it can do. Vague understandings of the technology are due, in part, to the inability of developers and researchers to agree on a definition of the medium. It is often unclear whether videodisc refers to the disc alone, the disc and its player, or the disc, its player, and a related microcomputer and its software.

We define the medium as a disc and any hardware (e.g., disc player, monitor, microcomputer) and software necessary for full play. Particularly with level 3 videodisc, in which a standard disc player is interfaced with an external microcomputer, neither the delivery system--the disc player and microcomputer--nor the disc alone define the medium.

Level 3 videodisc is best described by its features and benefits:

- Storage and preservation of visual images.

  Videodisc enables permanent storage and preservation of vast numbers of visual images. Archives, records, and collections of visual materials (e.g., photographs, films, stills, etc.) can be efficiently stored on videodisc. Videodiscs are also durable: they do not wear out, and images stored on disc never fade, become lost, or get disorganized.

- Convenient and compelling presentation of visual images.

As a projection system, videodisc may be easier to operate than other equipment and offers most of the advantages of other visual teaching and learning aids. Videodisc provides users with a single delivery system for presenting, on disc, materials previously available only on isolated media, such as television, films, filmstrips, and slides. These materials, when played on disc, are just as engaging, if not more so, because of the videodisc's keypad (and in level 3, computer) control features.

- High-speed, random access to images under user control.

Videodisc provides nearly instant nonlinear access and retrieval of any single still image or motion segment on a disc. This benefit, the key to interactivity, is not offered by any other high-quality visual medium; most, like film or videotape, require users to scan or search for images through a linear sequence. The ability to not only seek and view images in a random order, but also to replay, freeze frame, and play images slowed down, speeded up, or in reverse allows users to influence what is viewed and how it is viewed.

- Multimedia content.

Unlike most other media, videodisc materials can contain a mixture of audio, text, and high-quality visuals. The merging of information sources in level 3 discs offers an unparalleled opportunity for the development of innovative educational uses; videodisc is not solely a visual medium. Dual audio tracks permit two or more uses of the same text or visuals. New hypermedia software, such as Apple Computer's HyperCard, allows users to add text that interacts with disc images, as well as to sort and stack existing visuals.

New technologies will introduce additional features and benefits. DVI (Digital Video Interactive), a technology in development at General Electric and RCA, will offer: digitized graphics, which will let users grab, enlarge, and manipulate selected video screens; enhanced text and graphic overlay options, which will let users choose which visuals and text to merge and allow them to do so easily; and comprehensive single-unit design, which will combine a

laser disc player, screen, speakers, and computer into one system. DVI will also provide greater storage and memory capabilities.

Educational videodisc design approaches.

The degree to which a disc takes advantage of the medium's inherent qualities depends on its design approach. Most existing educational discs incorporate at least one of the following approaches: tutorial; master teacher; storytelling; problem-solving simulation; and visual database.

These design approaches are dissimilar; they are founded on different expectations about the medium, different teaching or learning objectives, and different assumptions about users--including how people learn. These differences influence the selection, organization, and presentation of disc materials, and so choice of content, sequence of content, degree and nature of embedded instruction, and the amount and types of interactivity vary among discs. Different design approaches empower discs with different roles, and these roles affect the degree of user control over content and process.

A videodisc **tutorial** is little different from a computer tutorial--except for the method in which information is presented: still photos and video sequences instead of computer graphics; narration and realistic sound instead of only computer text. Tutorials offer a body of information divided into lessons and presented in cumulative chapters. Chapters may contain several paths initiated by user responses, but movement through the disc is mostly linear and predetermined. Together, disc and computer take on the role of teacher and subject-matter authority and direct the conversation, while the user only reacts. Tutorials are designed to teach new concepts or skills, or to provide practice and review of lesson material already encountered.

The **master teacher** approach is a variation of the tutorial approach and is derived from how-to television programming. In master teacher discs, linear video sequences show an instructor demonstrating how to do an activity or create something. The master teacher is shown on screen or he or she narrates linear documentary sequences. The videodisc and computer become a medium for

presentation--they do not serve as a teacher, as in tutorials, but show a teacher in action. In other ways, master teacher discs resemble tutorials.

The **storytelling** design approach uses linear sequences (dramatic or documentary; fiction or nonfiction) to tell a story. Each side of a disc may contain a single story or there may be several stories per side. The sequences in storytelling discs may resemble movies, filmstrips, slide shows, or television programming. As linear storytellers, these discs require mostly passive viewing; they offer few opportunities for interaction between users or between users and machine except in follow-up chapters containing related questions and activities. .Storytelling discs tend to be more entertaining than educational.

Problem-solving simulations present real-life or hypothetical problems in highly interactive formats that require users to make decisions and manipulate variables in order to reach solutions. Usually both motion video and stills are used, and simulations may include tutorial-like sequences as well as surrogate travel or databases for research. As problem posers, these discs are lauded for promoting discovery learning and honing such skills as pattern identification and deductive reasoning.

Most **game** discs use a combination of design elements to create interactive activities involving logical reasoning, memorization and recall, decoding, experimentation (including trial and error and predicting outcomes), and drawing conclusions from clues or data. In strategy games, as in simulations, users must analyze alternatives and evaluate the consequences of their choices. Although these discs are more puzzle posers than gaming partners, they can be highly engaging and enable users to control the conversation. They usually have limited content but high entertainment and production values, which may make them less suitable for instructional purposes. But as with simulations, games can teach players important process skills.

Archival discs contain **visual databases** of still images and motion sequences usually transferred from other sources and organized by topic. The disc is the storage medium and the player provides unlimited access--both nonlinear and linear, controlled by the user. In level 3, a database manager or authoring system allows users to search quickly for images, and often also to sort and stack them in any order desired. Archival discs are used primarily as visual aids for presenting information or as research tools; they offer microworlds and multimedia resources without any instructional design. They are viewed by many educators as high-quality, compact, convenient, and economic alternatives to slide collections and other visual source materials.

3. Case Studies of Early Videodisc Use in Classrooms

Many secondary schools throughout the nation are experimenting with videodisc. Most of these schools have only a few players used by a limited number of teachers. We identified a variety of schools involved in early videodisc use and selected cases illustrating an array of use scenarios.

The case studies presented in this section are based on conversations with eight teachers from seven schools in Massachusetts, New Hampshire, New York, and Oregon. These case studies involve videodiscs with different design approaches in subject areas ranging from science to language arts, and typify a variety of teaching and learning situations, with both large and small groups of students.

Littleton High School.

In 1986 Betty Leonard, a biology teacher at Littleton High School in Massachusetts, saw something in a technology demonstration that she wanted for her classes--a level 1 videodisc player. Although her school was only just beginning to integrate computers into classroom teaching, the superintendent found a way to purchase a second-hand Pioneer 8200 player. Betty Leonard immediately began to use it with the "BioSci Disc" (Optical Data Corporation) in her ninth and tenth grade general biology lab. On days when the player is needed, it is moved from the Audio Visual room into the lab before class begins.

On a typical day, the videodisc player is placed in the front of the classroom. Leonard introduces the lab assignment during a lecture and uses disc images to illustrate some of the concepts and findings students will discover in their work. Once students break up into pairs to conduct experiments, they are encouraged to use the videodisc as a resource whenever they need additional information. Leonard lists relevant videodisc frame numbers on a chalkboard, and students use the remote control device to find the appropriate stills or motion video segments--showing, for example, tissue slides, stages of mitosis, and groups of microorganisms. The videodisc has even become useful during tests. Leonard shows images to the whole class,

and asks each student to identify, classify, or describe them on paper.

In this case study, a level 1 videodisc is used during a teacher's lecturing and test giving, and as a resource for student research. As a lecture and test support, the disc is used with the whole class and interaction is directed by the teacher. During labs, however, individuals and pairs of students interact with the disc directly for assistance with and reinforcement of their real-life lab activity. These multiple uses are made possible by frequent and regular access to the player and disc in the classroom.

Burlington High School.

Burlington High School is a large public school in the Massachusetts, Route 128 high technology belt and is committed to teaching with technology. Microcomputers are an integral part of many classes, including reading, mathematics, social studies, and science, and the school owns three videodisc players, ten discs, and LaserWorks authoring software. The school has a special lecture center equipped with a Nova Beam Projector, capable of providing large-screen display for computers, video, and videodisc.

Chemistry teacher David O'Hearn uses videodisc in his advanced placement chemistry class. The computer coordinator gave O'Hearn a videodisc entitled, "Chemistry: Titration and the Unknown" (Nebraska Videodisc Group). Although this is a level 3 videodisc simulation and lab tutorial, O'Hearn received the disc without any software or user manual, so, in effect, he had a level 1 disc containing short video segments. O'Hearn presents one segment from the disc, a short laboratory experiment on titration, in a linear format. With other materials on the disc, however, O'Hearn has used LaserWorks to create a text and visual database of definitions and techniques. Creating a database using the existing film was time-consuming, and O'Hearn spent many hours using 3x5 index cards to link short segments of the disc to a menu.

To teach his students about the titration process, O'Hearn first describes the concept to his whole class in a lecture setting. Then he sets up a lab class, one-and-a-half hours long, involving videodisc. He wheels the videodisc player into the front of the lab where it serves as a movie projector. Students watch the 8-minute linear

presentation about titration. After this segment, a menu appears on the adjacent computer screen and on the videodisc screen (by way of an Allen interface device). This menu, created by O'Hearn, lists the twenty-six definitions and eight techniques he wants the class to understand. After explaining the videodisc menu, O'Hearn wheels the videodisc to the side of the room. During follow-up lab work, pairs of students use the computer keyboard to search and play film clips, which clarify or review a specific topic or technique.

This case study illustrates how a teacher can modify the use of archival footage to suit an existing lesson plan. Using an authoring system, O'Hearn was able to repurpose video segments so that students can use the disc as a research tool to seek and find information about specific concepts and processes nonlinearly. O'Hearn invested considerable time programming the disc to fit his curricular needs and teaching style, and the result enables him to use the same disc as a documentary film with whole classes and as a scientific archive for pairs of students. Access to the original software designed for use with the disc by the publisher, or at least to a list of the videodisc images, would have made O'Hearn's effort to tailor-make videodisc presentations simpler and quicker.

Oyster River High School.

Oyster River High School is a public school in the university community of Durham, New Hampshire. A model site for the Governor's Initiative Program for computer and videodisc equipment and support, the school contains about 75 computers, an in-house videotape production and editing facility, and a growing collection of videodisc players and discs. School administrators have a vision for videodisc use and plan to create a resource room containing players and a library of discs. Satellite machines will rotate through classrooms in each department. At present, the school owns eight Pioneer players, about forty disc titles, and the LaserWorks authoring system. Teachers are encouraged to experiment freely with videodisc, particularly with level 3 uses.

A science teacher, Doug Knight, teaches a year-long course on the creation and presentation of videodisc astronomy lessons for the student-run school planetarium. His 11th and 12th graders are each responsible for choosing a topic, planning a lesson, programming the

videodisc, and then presenting the videodisc lesson in teams to students from local elementary schools. The class takes place in the planetarium, which is equipped with a videodisc system.

During the first semester, Knight teaches students how to plan and make a videodisc presentation. Knight suggests topics and serves as a content consultant and facilitator to students planning their original videodisc presentation. During the second semester each student is given one day to program the disc, using LaserWorks to select and arrange the images from two archival discs, "The Space Disc" (Center for Aerospace Education on Astronomy) and "Space Archives" (Optical Data Corporation). Presentations are designed to direct viewer's attention back and forth between night sky images in the dome overhead and videodisc images on a monitor in front. Students, in teams of three, give four presentations a week to younger students.

This case study illustrates a constructive use of archival discs in which students actively work with existing visuals to make their own videodisc presentations. For the students involved in the creation process, videodisc served as a tool for manipulating images. Knight believes that by manipulating images in an atmosphere of cooperative learning, his students verify what they know as well as reach new insights. For the audiences of younger students, videodisc served as a presentational medium that complemented conventional planetarium teaching methods.

The McKelvie School.

The McKelvie School in Bedford, New Hampshire, is one of six pilot sites for the development of videodisc materials on language arts for middle schools. This work, supported from the Governor's Initiative Program, involves a group of teachers who are using videodisc images and LaserWriter to create lessons on spelling, grammar, and writing. Seventh grade English teacher Frank Zito, the first in his school district to incorporate videodisc into the classroom, was loaned a videodisc system and discs by the state pilot technology program.

Zito began using videodisc extensively during the 1986-87 school year. He uses "The History Disquiz," a game disc featuring historic news footage. What students view, however, is not a game disc but programmed instruction; a group of language arts teachers used

"LaserWriter" to create a level 3 videodisc curriculum for teaching journalism skills.

During a typical session, Zito gathers his class around a 20" screen to watch archival news footage documenting three historic events: Lindbergh's flight, President Kennedy's assassination, and the accomplishments of the Flying Wallendas. Before each segment, Zito introduces the event using the previewing questions written for the disc. During viewing, students take notes about the events. After each segment, Zito reads aloud from the screen a series of postviewing multiple-choice questions. The students view the segment a second time to see what details they missed. Students respond on paper, and then compare their answers to the preprogrammed disc answers. The teacher directs students' interactions with the disc and facilitates discussion of the historic events.

That night, as a homework assignment, students write a newspaper story based on one of the historic events they viewed as "witnesses" and discussed in class. The next day students share their articles with the whole class, and compare their stories with an actual news article of the event. Students who need additional help check their articles for accuracy by reviewing the videodisc segment, either individually or in small groups. Through this assignment, students gradually work toward the goal of writing their own full-length newspaper article based on a current event.

This case study illustrates how a game design approach can be repurposed to serve instructional goals. A group of language arts teachers used original source materials on the quiz disc to create a level 3 storytelling disc with tutorial-like previewing and postviewing questions that enable students to hone their journalistic writing skills. The historical images generate class and small-group discussion, and spur individual research and writing.

Taft Middle School.

The principal of this inner-city middle school in Boston has transformed the school into a place where teachers are excited about the potential of technology, where technology has been integrated into the curriculum of every subject area in the school, and where students always have access to a computer. Students usually work independently with computers, sometimes in a classroom and other times in a computer lab. The school does not have any videodisc equipment, but was selected as a site for pilot testing a prototype level 3 videodisc, "Seeing the Unseen," created under the auspices of Harvard's Educational Technology Center.

A seventh grade teacher, George Moran, piloted one lesson from the disc, which employs tutorial and archive approaches to teach science topics. The lesson includes a video introduction and structured activity in which students are asked to categorize the types of animal disguises revealed in twelve video sequences of animal behavior. The lesson was piloted during a single class period, 50 minutes long.

Moran set up the videodisc system in the front of his classroom and the entire class viewed the lesson introduction. Afterwards, students read a page on animal disguises from their textbook. Moran then questioned students to verify their understanding of the material and provided additional information to clarify concepts. Next, the class viewed video sequences about animal disguises and participated in a classifying activity. Moran read aloud the directions and information on the screen, and directed different students to touch the screen to move ahead in the lesson, to stop or replay the sequences, or to choose an option such as viewing a sample chart.

Occasionally the teacher would focus student attention on certain aspects of the video, (e.g., Does anyone know what that animal is?") and would follow-up with more detailed information than was available on the videodisc. Students often asked for a video sequence to be replayed so they could observe an animal again. Sometimes the students asked Moran to clarify a term heard in the narration. Moran allowed students to set the pace by always asking if they were ready to move ahead to the next sequence. A few times, Moran stopped the presentation and questioned students about what they were viewing and what conclusions they were reaching.

Following the videodisc presentation, Moran summarized the material and clarified instructions for a paper and pencil classification activity. He further reinforced the material through a brief question and answer period. When this discussion revealed student confusion, Moran offered additional information and asked students to talk more about what they had seen on the disc.

This case study profiles the use of a tutorial approach with a large group of students. The disc served as a means of presenting visual material to an entire class of students who worked through an activity simultaneously in a sequence and pace directed by the teacher. Moran played a central role, steering his students through the lesson, providing additional instructional structure, and continually questioning and clarifying to reinforce content. Although students had the benefit of the teacher as a group leader and subject matter authority, their ability to interact with the videodisc was constrained both by Moran's role and by the function of the group.

da Vinci Alternative School.

The da Vinci Alternative School is a public school in Eugene, Oregon dedicated to exploring the use of technology in the classroom. The school uses computers across all grade levels and subject areas. There are 120 computers located in five classrooms, a ratio of one computer per student. The school houses three of the five videodisc players owned by the school system. Although other schools may occasionally borrow a player, teachers at daVinci always have access to a player if they need it.

Sam Miller has been using the level 1 videodisc series "Core Concepts in Mathematics and Science" (Systems Impact) for three years. His sixth, seventh, and eighth graders work with three discs from the series, "Mastering Fractions," "Decimals and Percents," and "Mastering Ratios." The discs are tutorial in nature--in each chapter or lesson, a host introduces, explains, prompts, drills, and then tests students on specific math skills. The instructional package contains an instructor's manual with educational objectives and booklets in which students solve problems provided by the disc.

Miller uses a large-screen monitor to present the videodisc images to an entire class of 20 to 30 students. While the disc presents a lesson

on fractions, for example, Miller circulates through the room checking students' work and assisting students who are having difficulties with problems. When the disc reaches a built-in stop point, Miller uses a remote control device to choose the next pathway through the lesson depending on his assessment of his students' need for review or remediation. Stop points also enable Miller to control the pace of the lesson. The videodisc lesson sometimes asks for an oral response, and the students respond in unison. At the end of the lesson, students take a test prompted by questions on the videodisc.

This case study illustrates how a very structured tutorial disc with a master teacher approach can be used in a formal classroom setting. The teacher has the disc provide instruction, freeing him to give personal attention to the many students in his class; Miller is more of a manager, resource, and personal advisor, than a knowledge teller. Using the disc to present instruction also saves Miller class preparation time.

Shrewsbury High School (#1).

Shrewsbury High School, a large suburban school in an affluent suburb outside of Boston, supports technology use in all subject areas. It has computers, VCRs, and televisions, and a single videodisc player. The videodisc player resides on a cart wheeled from class to class, and is permanently hooked up to a 26" monitor and a Macintosh computer so that HyperCard software can be used to access disc content. The school owns several archival discs, including Optical Data's "Earth Science Disc" and "Life Science Disc," and has provided in-service training to teachers on equipment and disc use. The disc player and discs have been in the school for about three months. They are primarily used by three science teachers.

One biology teacher, Ralph Mastrorio, reserves the videodisc player and the "Life Science Disc" for use in his classroom every day during a six-week period devoted to the study of animal structures. Each of his classes contains a heterogeneous group of 20 to 25 students within a single grade: ten, eleven, or twelve. During the unit, students dissect eight animals, ranging from a mollusc to a fetal pig, in double lab periods of 90 minutes.

Rather than setting up a traditional school lab in which pairs of students dissect a specimen and record data about anatomy, Mastrorio divides his students into groups of three who work as a team to investigate the whole animal, including its physiology and habitat in the wild. Their assignment is to create a report for each animal using information gathered from four sources: dissection specimens, computer software, videodisc and related HyperCard stacks, and print materials.

Guided by lab packets containing information and instructions written by Mastrorio, the students circulate among the resources. Each team member is responsible for one assigned task: animal dissection; technical drawing; and the natural history of the organism. Students investigating the natural history use the videodisc as one of their resources. During any lab period, students are dissecting specimens, searching a software database running on an Apple IIe computer, and using HyperCard to view slides and short films on the "Life Science Disc." Books and magazines from the school library are consulted by team members as needed. As the students work, Mastrorio circulates through the classroom answering questions, solving logistical problems, and monitoring student progress. Mastrorio is, in fact, a fifth resource who is more likely to address questions of process than of content.

Science labs at the high-school level are classrooms which traditionally enable students to pursue research questions through cooperative learning with the teacher acting as an enabler. Dissection specimens and print materials are usually available. And more and more often, microcomputers are permanently residing in science classrooms. Directing teams of students to use an archival disc as a research tool is a natural extension of these conventions.

Shrewsbury High School (#2).

In the same school, Bob Cornacchioli uses the "Earth Science Disc" with HyperCard about once a week in each of his classes. He teaches eighth graders in heterogeneous groups of 20 to 25 students. They spend some days in whole-class lecture and discussions, some days in lab, and other days preparing for or taking tests. Cornacchioli believes his students learn best when they experience new information in a variety of ways: by reading text, viewing visual images, listening, watching, and drawing. The videodisc is used in his classroom for lecture and discussion support, and for reviewing material before an exam.

On the day Cornacchioli begins a new subject, volcanic activity, students come to class having read the chapter on volcanos in their textbook. Before they arrive, Cornacchioli writes definitions of the three main types of volcanos on the chalkboard. As he lectures, he stands beside the monitor in front of the class and directs a student to use the HyperCard menu to find the disc visuals related to the topics addressed. Students ask questions and often help decide what they should look at on the disc. Still and motion images serve to introduce and explain concepts and phenomena. Cornacchioli uses the HyperCard text that accompanies stills as cue cards for his lecture, though sometimes he reads captions aloud to students.

During subsequent days, the class will have labs on related subjects, such as the process of mountain building. Prior to the test on volcanic action, Cornacchioli will have an open class in which students can either participate in a question and review session with him, sit at their desks studying, or review material on the videodisc. The disc is not, however, used during the test.

Cornacchioli prefers to select and order stills from the disc before his class presentation. However, because the videodisc player is frequently unavailable during his free hour, he often uses the first class period in which disc visuals on a specific topic are used to create the presentations he will use to teach the same topic to his other classes. Noting that VCRs are far more common in his school than videodisc players, Cornacchioli has requested permission to videotape his videodisc presentations so he can have ready access to his personalized image collections whenever he wishes.

Cornacchioli uses a traditional lecture-demonstration teaching method when presenting new information. He likes to be in command of the content throughout his presentation and he likes to choose the visuals to support it. To him, the "Earth Science Disc," supported by HyperCard, is a convenient means of presenting material previously only available on slides, filmstrips, and films.

To use an archival videodisc in such a controlled manner requires a teacher to take the time to prepare the presentation--select and order images--outside of the classroom during his or her free time. The access difference between Mastrorio and Cornacchioli, who both teach in the same school, has to do with access outside of class--the biology teacher can reserve the player and disc for his class, and so can the earth science teacher. But to create presentations, Cornacchioli needs the equipment to be free when he is free, and this rarely happens. Cornacchioli's request to videotape his videodisc selections is a logical response to this access problem.

Belmont High School.

Martha Reagan, the librarian at Belmont High School, has been one of the main initiators of using technology in her school. Although Belmont is a wealthy suburb of Boston, their funds for technology are limited. Last year they equipped the library with three computers for independent student use and there are fourteen computers used primarily in school business courses. The school also has an old level 1 videodisc player. Reagan wrote and received a Commonwealth In-Service Grant from the state that funded a series of workshops to familiarize teachers with videodisc technology. Soon after, at Reagan's initiative, the school budget paid for a new videodisc player that could be hooked up to an Apple II computer in the library.

A math teacher, Alice Mandel, participated in the videodisc in-service workshops and last year tried out interactive videodisc in two of her Algebra II classes with eleventh and twelfth graders. Using an Apple software program, Mandel repurposed a level 3 simulation videodisc into math lessons, using "Puzzle of Tacoma Narrows Bridge Collapse" (Wiley Educational Software). Mandel uses the disc to teach the connection of graphing sine and cosine functions with the standing wave pattern of a bridge before its collapse.

As a whole class, students watch an introductory narrative about the history of the bridge and an explanation of wave patterns. At a built-in stop point, Mandel directs several volunteers to trace, on a plastic covering over the screen, the wave patterns of the collapsing bridge and then compare their tracings. Mandel focuses student attention on the relevant aspects of the disc presentations, controls the pace of the lesson, and directs students' interactions with the disc. At the end of the videodisc lesson, students view the final collapse of the bridge. Following videodisc use, Mandel leads a class discussion on the lesson concepts.

Mandel has used the videodisc for in-class demonstration purposes, but would like to involve students more actively. Ideally, she wants the computer to handle all interactions so that students can use the disc independently of the teacher. Mandel sees her role as a discussion leader following independent videodisc use.

Although funds for technology are limited at Belmont High School, Mandel is working in a supportive environment that provides her with both in-service videodisc training and a videodisc player with discs. Restructuring the videodisc using Apple software enabled her to fashion a videodisc simulation into lessons that serve her curriculum goals. Mandel's role was primarily to manage student's interactions with the disc, and provide follow-up instruction clarifying the lesson concepts. Realizing the limitations of whole-class use of the disc, Mandel looks forward to allowing small groups of students the opportunity to use the disc more actively and more independently.

4. Discussion: Variables Influencing Early Videodisc Use in Classrooms

The case studies show that videodisc design approaches and the educational context are factors in a complex equation that influences how videodisc is used in the classroom. In this section, we examine the case studies of early disc use to discuss these two sets of variables and how they interact.

Videodisc design approaches and their effect on disc use.

Every videodisc use begins with a disc. The disc itself is what a teacher or a learner has to work with, and it comes with different potentials and constraints depending on the design approach or approaches incorporated. Educational design approaches appear to differ in three key ways: models in other media, suitability to the videodisc medium, and instructional methods and goals. Together these differences seem to define how adaptable a disc is to a variety of classroom purposes.

• The discs used in the case study classrooms were often modeled after materials from other educational media. Frequently, visual images appeared to be transferred directly to videodisc from films, filmstrips, and slides. And identical formats were as common as identical material. Storytelling, game, and archival discs are direct descendents of books, films, microcomputer adventure games, and slide collections. Tutorial discs and disc simulations are modeled after computer tutorials and simulations; master teacher discs are modeled after how-to educational television.

Visual images and formats for educational discs are copied from other media because, as a presentational medium, videodisc combines many of the best features of other media, both low tech (e.g., slide projectors) and high tech (e.g., microcomputers). It also makes sense that early disc developers are looking to related media for inspiration and models since their design objectives are often similar to the purposes served by other technologies.

The borrowing of approaches from other media is producing many effective disc designs, but this practice may also stifle innovation. Many disc designers appear to be translating a known design

approach, such as linear storytelling, without considering videodisc's special capabilities beyond its convenience as a projection system. Furthermore, some disc designers do not seem to analyze videodisc features and benefits and decide how to take advantage of them by altering accepted approaches or by experimenting with new approaches. Rarely do the design approaches of one medium precisely suit another.

• The design approaches of the discs used in case study classrooms exploit varying combinations of the medium's inherent qualities. Tutorials, storytelling, and other approaches modeled after formats used in other media, were least likely to fully exploit unique videodisc features such as nonlinearity and vast storage capacity. Approaches that portrayed bite-sized portions of highly visual material, such as archival discs, were most likely to enable users to take advantage of what videodisc does well--random, nonlinear access to large quantities of highly visual, multimedia content.

As seen in Oyster River High and Shrewsbury High, archival discs enabled teachers and students to control both content and presentation. Other disc packages enabled users to control the pace or path of presentation, but not the breadth and depth of their exposure to content. When a disc design is modeled after applications in another medium, it tends to carry with it some of the limitations of the other medium and exploit few of the unique features of videodisc.

It is important to remember that by providing visual information, and often also textual and audio information, videodisc is a content-rich medium. It cannot exist without visuals, and visual images always have subjects and meanings--videodiscs rarely present value-free content. Because it has built-in content, videodisc is not a tool in the same sense as a word processor, database manager, or spreadsheet program. Videodisc is less a structured or unstructured shell awaiting a user's input than a flexible projection system for an ordered collection of visuals managed manually or through a microprocessor. Although users cannot create new video images using an existing videodisc, at level 3 the technology is a tool to the extent that it allows users manipulation of images. Users can select, sort, or stack videodisc material, and have video control over motion segments. In addition, new software such as HyperCard lets users create drawings and text to accompany disc images.

• The different design approaches of discs used in the case study classrooms also differed in their instructional methods and goals, and this affected what they offered users--facts, concepts, and theories or a learning environment for exploration and problem-solving. This was most often related to a varying emphasis on curricular content versus process, the level of skills (basic or higher order) stressed, and the differing roles played by the technology and disc, teachers, and students during use. Generally, the less built-in structure and instructional design a disc contained, the more ways it was used.

For example, in tutorials, the objective is to portray a body of information for a student to memorize and comprehend. While the disc program may offer options in path and pace, these options are predetermined. The disc program appears to serve as a relatively rigid teaching machine, and the machine controls the interaction even if it is directed by a teacher or other user. At the Taft Middle School and at the da Vinci Alternative School, for example, tutorials were used with whole-class groups. Every student had to participate at the same pace and along the same path. In fact, students were two steps removed from direct interaction with disc content: pace and path were directed by the teacher, but only according to the options offered by the disc. Even if students had used these discs alone or in small groups, they still would have had their interaction mediated by organizational structures and instructional guides built into the disc design.

Among simulations, users usually have more control (the disc program serves as both a problem poser and information provider), but the presentation is rarely open-ended--content is still highly structured and either the program or a teacher may set the agenda for disc use. The process of fact finding, however, is as critical as the content considered, and students exercise high-level thinking skills, including analysis, synthesis, and evaluation. At Belmont High, use of a simulation disc with a whole-class group provided students with an engaging application of mathematical formulas. Students were able to closely investigate an event, although opportunities for manipulating the event or accessing additional information were limited by the disc's structure and content.

The same thinking skills used with simulations are required by users of archival discs. But by accessing and manipulating data, the user is in charge of the interaction and uses the disc program as a tool for

finding things out and discovering relationships. For students and teachers at Shrewsbury High, Littleton High, and Oyster River High, interaction with archival discs was not mediated by organizational structures and instructional guides--by design, these characteristics are invisible except as navigational aids, or are absent altogether. Users have direct access and control over content, and when creating new constructions, they are free to make their own formats.

• Lack of adaptability to support different teaching and learning styles may be the most lasting drawback of basing disc design on models from other media, of ignoring unique features of videodisc technology, and of building in instructional methods and goals. The case studies reveal that the more adaptable a disc is to the existing educational context, the greater its range of uses and roles.

Some disc designs offered little instructional flexibility to teachers and students, and thus supported only specific use modes. Tutorials, for example, presented content of a specific level within a highly structured instructional context that gave users little control beyond the choice of alternate paths. While tutorials can be used with whole classes, small groups, or individuals, their role in the case study classrooms was always the same: to teach someone something specific in a predetermined manner. The Taft, Burlington, and da Vinci schools indicate this role requires teachers and students to accept the disc as an information provider and authority that either monopolizes the conversation or is interacting with the teacher while students participate at a distance. Teachers become managers of the student-disc interaction while students become largely passive consumers.

Like tutorials, most storytelling discs are linear and offer few opportunities for input by teachers or learners over how, when, and what data is presented. Simulations offer additional flexibility, but they are usually targeted at individuals and small groups so that use by whole classes can be cumbersome; simulations require students to participate actively while the teacher plays only the role of facilitator. Archival discs are the most open-ended; they offer little structure beyond the organization of visual data. Thus, they offer the most flexibility to teachers and learners, and can be used to support nearly any teaching and learning activity.

The case studies show that the range of uses increases as videodisc built-in instructional design decreases. For example, each time a tutorial disc appeared in a case study (Taft, Burlington, and da Vinci), it was used primarily for teacher-led exposition or review in front of a whole class. Each time an archival disc appeared (Oyster River, Shrewsbury, Littleton), it had a slightly different use: displaying visuals for an entire class, a learning station for small group investigations, a multimedia database for creating presentations, and a reference for individual research.

Disc design also seems to affect the amount of preparation time required prior to disc use and the amount of time required for disc use. Not surprisingly, the case studies indicate that the less a teacher or student depends on a built-in instructional design, the more time is required for preparation. Tutorial discs required the least amount of teacher preparation, and archival discs the most--if they were used to create original presentations. Because they have built-in lessons, highly structured discs, including simulations, also tended to present specific time demands. Sam Miller at the da Vinci Alternative School and many other teachers had to plan the length of videodisc use in their classrooms around the predetermined lessons on a disc.

Disc repurposing is often a sign of conflict between built-in design approaches and a teacher's desired classroom use--it is a teacher's way of making a disc fit his or her style or intended activity. Frank Zito at the McKelvie School used a repurposed game disc to achieve the effect of an archival disc with some tutorial-like qualities. David O'Hearn at Burlington High repurposed a chemistry disc to more specifically fit his curriculum.

Educational context and its effect on disc use.

When first used by mainstream schools, videodisc seems to enter an educational environment in which ideas about how to teach and learn using technologies are already established. These ideas, and the theories about teaching and learning they encompass, as well as the use patterns they lead to, are garnered from years, often decades, of experience with such devices as record players, tape recorders, slide projectors, film strips, films, television, and microcomputers. The case studies show that for videodisc, three key factors seemed to create the specific context for disc use: the teaching and learning activity; teachers' and learners' access to videodisc equipment; and school culture.

• Teachers and students used discs in different ways depending on their teaching and learning activity. In the case studies, teachers and students used videodiscs during three major kinds of activities: lecture-demonstrations and discussions; discovery-oriented inquiries; and independent research. These activities often required different classroom organizations, teacher roles and teaching styles, and levels of student participation. These activities also made different demands on the medium. Each type of activity appears to have characteristic use patterns.

During lecture-demonstrations, videodiscs supported whole-class instruction in two ways. At Littleton High, the McKelvie School, and in Shrewsbury High, the teacher stood in front of a class, presenting concepts and describing phenomena illustrated by disc visuals. Sometimes the information served to initiate discussion, review previous instruction, or introduce or provide closure for other disc activities. Regardless, the teacher structured a very directed learning environment in which his or her role was to direct and control the acquisition of new information using the videodisc.

At Burlington High, Taft Middle School, da Vinci Alternative School, and Belmont High videodisc supported lecture-demonstration in another way. Teachers stood aside and let the videodiscs present the lessons; they managed learning environments structured by the videodisc. Teachers directed student input into the videodisc lesson and regulated pace and pathways taken through the disc lesson. In both types of lecture-demonstration, however, teachers directed a central forum in which they controlled the acquisition of information using the videodisc as a resource.

During discovery-oriented activities, videodiscs served as learning stations for investigating topics or constructing original presentations. In most cases, these exploratory activities involved small groups of students working as a team while other activities occurred simultaneously in the classroom. At Shrewsbury High, for example, students used an archival videodisc and related HyperCard stacks to investigate the physiology and habitat of animals. At Oyster River High, students used archival videodisc material to construct an astronomy videodisc presentation for younger students. In both cases, the students engaged in cooperative learning while the teacher served as a facilitator by posing problems for investigation, answering questions, and providing additional information.

During research activities, videodiscs were used as references or quick sources of information for individual students or small groups during relatively unstructured classroom time. At Littleton High, for example, the "BioSci Disc" was used to get additional information needed for laboratory work. At Burlington High, students followed-up on a titration lesson by searching the videodisc for definitions of scientific words or descriptions of scientific techniques. At the McKelvie School, students reviewed videodisc material to look for details they might have missed during the whole-class presentation. And in the earth science class at Shrewsbury High, students used a disc to review for a test. Generally, teachers were not directly involved in these independent research activities; working alone with the technology enabled students to receive remediation and fulfill other individual needs.

• Access to videodisc equipment affected how discs were used in classrooms. In most of the case studies, videodisc equipment was limited to one or two players and a handful of discs per school. Teachers negotiated use among themselves, and the mobile equipment circulated through several classrooms and labs. Access by teachers to videodisc equipment outside of the classroom was rare. This degree and type of access influenced the ways in which case study teachers and students could use the technology. Even teachers working in schools with several players and a library of discs had less access to equipment than they wished.

When equipment is shared, teachers cannot expect to use videodisc in their classrooms more than a limited number of times during a given week or month. In several of the case studies, including the

earth science class at Shrewsbury High, videodisc was used less than once a week. Limited access means that videodisc appears infrequently and irregularly in many classrooms.

Limited access also means that when videodisc does appear in the classroom, it tends to be used in only a select number of ways. When teachers cannot spend as much time as they wish familiarizing themselves with disc materials and customizing programs outside of class, and when they must make decisions about when disc use is a priority, they tend to depend on disc design approaches to guide their classroom uses and to employ videodisc rigidly to attain specific teaching and learning objectives. In Littleton and Burlington high schools, for example, discs were used over the course of a curriculum unit, but only as a projection system for visual images during lecture-demonstrations, lab work, or test preparation.

Periodic use for specific, short-term purposes and dependence on built-in disc designs are natural outcomes of limited access. Spontaneous and more innovative (and often more time-consuming) uses seem most likely to occur when teachers have access to equipment outside of class, and when videodisc has an ongoing presence in a classroom and is viewed by teachers and students as an integral part of everyday activities. A high degree of access to videodisc equipment seems to contribute to the use of videodisc as both a teacher's tool and a student's tool.

The students at Oyster River High, for example, have regular access to a videodisc player for creating their planetarium shows. Frank Zito's English class at the McKelvie School has videodisc equipment available for daily use--they use a repurposed "History DisQuiz" to view footage and write stories from original source materials. Ralph Mastrorio's biology class at Shrewsbury High uses videodisc in the lab every day for eight weeks; the player and disc serve as a classroom-based research center. Even in schools where equipment is shared, concentrated use over several weeks frees teachers and students to explore multiple and highly creative uses.

Degree of access to videodisc equipment also influences how many students use a disc at a time. The case studies indicate that teachers work to achieve the greatest degree of exposure for the greatest number of students; when access is limited, whole-class use is more common than small-group use, and small-group use is more common than individual use. Among the case studies, individual

and small-group use only occurs when videodisc equipment remains in the classroom or lab for several consecutive class periods, or when students can visit the equipment at a site where it resides permanently. The size of classroom groups using videodisc equipment also influences and is influenced by the type of learning activity undertaken and the type of disc selected by the teacher.

• School culture influenced how discs were used in classrooms. The case studies reveal that the expectations and attitudes of a school community or school system toward teaching with videodisc can affect how individual teachers use discs in their classrooms. All of the case studies represent school systems that are experimenting with videodisc--they have the interest and ability, if not the money, to explore educational uses of the technology. Even so, two different types of school culture emerged. These cultures vary in the extent to which they view videodisc use as central to the teaching and learning process.

One school culture, typified by Oyster River High and Shrewsbury High, supports the integration of technologies into a broad curriculum. These schools provide teacher training, encourage adoption and experimentation with technology-based materials and teaching methods, and, given the resources, would provide regular and frequent access to videodisc in many subject areas. Members of this school culture believe the technology can empower both teachers and students by providing intellectual control over visual, audio, and text information.

These schools, which foster a climate in which interactive technologies are viewed as tools, not simply teaching machines or projection systems, tend to purchase certain kinds of discs and promote certain kinds of uses. Teachers were most likely to have students work with visual databases during small-group exploration and the creation of original presentations. These uses incorporate videodisc into classroom activities, underscore videodisc's function as a research resource and visual projection construction set, and enable users to be manipulators not just consumers of information.

In the second type of school culture, typified by Burlington High, the McKelvie School, and Littleton High, videodisc is viewed as an engaging means of supplementing or complementing instruction in certain subject areas, particularly art and science. Some teacher training is offered, but there is no intention of fully integrating videodisc into teaching and learning activities. Authority for decision-making about technology use tends to be more centralized in these schools, and for the most part, videodisc is viewed as a teacher's aid--a piece of audio visual equipment that excites students and makes teaching easier.

These schools, which view videodisc largely as a presentational medium, to be used like a film or slide projector during special class occasions, also reveal patterns in disc preferences and uses. Teachers were most likely to use tutorials, problem-solving simulations, and visual databases while lecturing or leading a discussion involving a whole class of students. When students used discs alone or in a group, it was almost always to achieve explicit objectives requested by the teacher. These uses support a teacher's role as a knowledge giver, and encourage him or her to retain intellectual control of disc interaction and students' exposure to information.

Occasionally, a teacher's desired use clashes with his or her school culture. Ralph Mastrorio's wish to videotape different paths through the "BioSci Disc" (a visual database) is antithetical to Shrewsbury High's unstated preference for tool use of discs. The school encourages teachers to create personalized tours on different topics using the archival disc, but videotaping the tours would have resulted in linear video presentations that would negate nearly every reason for using videodisc in a classroom.

5. Conclusions

Our study has shown us how teachers and learners are experimenting with videodisc in secondary schools and what factors are contributing to these uses. Assuming that our case study sites are typical of many secondary schools, we can make several inferences about early videodisc use in education. These inferences lead us to suggest uses for videodisc that apply new understandings about teaching with technology in ways that are appropriate to videodisc and to mainstream schools.

Trends revealed by the case studies.

Generalizing from our case study findings, we believe that in its earliest, widespread uses, videodisc will probably be adopted and adapted first in ways that suit the existing school context. While videodisc and other new technologies may ultimately have an impact on education by suggesting and supporting innovative teaching and learning, they may first offer easier or improved ways for educators to do what they already do or give them opportunities to teach as they wish they could.

The trends we point out might serve as useful questions or issues for future research. Very few studies have examined how technology actually gets used in classroom settings at the secondary level. Most studies of videodisc use assess adult training in business and industry; studies of videodisc in schools focus on learning scores or examine discs in situations removed from classroom activities. In contrast, research at the Harvard Educational Technology Center and at the Bank Street Center for Children and Technology has led to in-depth studies of classroom use of computers and videodisc. This research, along with a few other isolated studies, supports the trends we discuss below.

1. Teachers are a critical factor in videodisc use. Our case studies show that teachers may operate within the constraints of school culture, limited access, and disc design, but they determine when, how, and why a disc is used by structuring and managing the learning activity. Teaching and learning activities differ depending on how much direction and structure is provided by the teacher and who is

in control of the learning process, and these factors influence the way teachers choose to use videodisc.

Teachers use videodisc in a variety of ways, including as a presentation tool for classroom groups or as a learning station for small groups of students. For most uses, videodisc, rather than replacing teachers, requires a range of roles from that of director of the learning process, to guider or facilitator, to resource person or knowledgeable collaborator.

Other researchers have also highlighted the importance of the teacher's role in using technology in the classroom. Char (1983) observed in her field study that different ways of using software were partly due to "the degree and type of teacher involvement" and "the ways teachers organized their classrooms" (p.3). In a review of the literature, Wiske et al. (1987) emphasize the central role of the teacher in implementing new instructional practices. Glenn (1983) and Hofmeister (1985) report that videodisc, rather than serving as a replacement for teachers, is often viewed as an instructional tool under the teacher's command.

Char (1983) also found differences in software use due to teaching style. Some teachers in her field study took the role of demonstrator, whereas other teachers served as resource people or as "software managers" for students working independently with the computer. Storey and Julyan (1985) in a study of classroom use of curriculum packages that integrate television, software, and print found that teachers took on a variety of roles while using the packages, including the role of collaborative investigator and of facilitator. They conclude that successful use of integrated packages depends on the skillful role of the teacher as facilitator, rather than as a didactic lecturer. Wilson (1986) reports, based on Harvard's Educational Technology Center research, that "The learning outcomes computers promote will depend almost entirely on the choices that teachers and administrators make about how to use them" (p. 8).

Sometimes the videodisc design approach seems to influence the teacher's role. The more structured the videodisc, the more the teacher assumed the role of a guider or facilitator. The more unstructured the videodisc approach, the more the disc was adaptable for a range of teacher roles and teaching and learning activities, and the more both the teacher and the students played an

active role. Thus, although teachers are a critical factor in classroom use of videodiscs, the videodisc design approach can influence the type of teaching role.

2. Most teachers integrate videodisc into already established teaching methods and activities. In the case studies, most of the videodiscs were used as sources of visual images to support conventional educational approaches, including teacher's lectures and student's lab work.

Disc designers are mostly creating discs with familiar instructional approaches, and likewise, teachers are choosing discs with familiar formats--ones that mimic what they do or what other media do--and with content matched to their curricula. These familiar approaches, especially discs designed to be used for whole-class presentations, seem the most easily integrated into the existing classroom environment.

Jackson and Deal (1985) observed in a study of classrooms using computers that it is more difficult for teachers to use technology to guide and critique than to engage in direct teaching. They believe that new technology and teaching methods may bring only gradual change in the way teachers approach teaching, because teachers are part of a "well-established, slow-changing system" (p.106). Char and Tally (1986) in their classroom study of videodisc use observed that videodisc models appropriate for whole-class presentations were more easily integrated into the existing classroom structure than models requiring independent student work. Other research (Berman & McLaughlin, 1974 and 1977; Doyle & Ponder, 1977; Farrar et al., 1981; Sarason, 1971) has also shown that teachers' accustomed practices and their school context and culture greatly influence the ways teachers adapt educational innovations. Engaging in nontraditional teaching roles can be difficult for many teachers who do not have the experience or the support of school administrators, and whose teaching approaches are a result of well-embedded teaching traditions.

Teachers seem to choose discs first for content and then for format. They match content to what they teach, recognizing that depending on the design approach, they can alter, supplement, or even completely override disc formats by informally directing disc use or by formally repurposing a disc with software. However, some

teachers prefer to use the built-in disc lessons, freeing them to give individual attention to students.

In many of the case studies, teachers used discs--regardless of videodisc design type--in ways that suited them, not necessarily in ways intended by disc designers or in ways that take advantage of what videodisc does well. Most teachers were looking for ways to do what they are already doing better--they wanted to capture student attention and they wanted easier and more engaging ways to present their curricula. Vast storage potential, user control, interactivity, and other unique benefits of the videodisc seem to mean little to teachers unless they have practical implications.

3. Limited access to videodisc usually means shared use, and shared use has significant implications for teaching and learning with the technology. When videodisc first entered a case study school, it was usually as an experiment in which one or two pieces of equipment (along with discs) were made available to several teachers. Even when equipment was in plentiful supply, a discrepancy existed between the amount of equipment and the number of interested teachers and students. This discrepancy automatically established constraints on access that affected the placement of the technology and its ultimate use pattern.

As typical of microcomputer placement, case study schools managed videodisc access in two ways: 1) place each unit on a separate mobile cart that can be wheeled from classroom to classroom on a period or daily basis; and 2) place one or more units in individual classrooms for a week or longer. A third alternative, placing multiple units in a fixed lab, was planned for Oyster River High when the number of disc players reached a critical density.

Many case study schools regulated access to provide the largest number of teachers and students with the greatest amount of exposure. This objective meant that regardless of which placement solution a school tried, limited access to videodisc usually led to shared uses during class sessions. Whole-class instruction provides the greatest exposure to the medium when time is limited; small-group and individual uses require extended access if all students are to have an opportunity to use the technology. In their study of videodiscs in schools, Char and Tally (1986) conclude that videodisc

use with whole classroom groups maximizes the participation time of each student.

The case studies show that whole-class uses with videodisc differ substantially from small-group and individual uses. When videodisc is used with large groups, it is usually during lecture-demonstrations in which the teacher controls the interaction--students have relatively passive experiences as the objects of instruction. When videodisc is used by small groups of students and individuals, it is most often for research and investigation or the construction of original presentations--students frequently have active experiences in which they direct the learning process, if not the content of what they are learning as well.

The effect of access on group size and type of exposure in schools has been documented for microcomputers. For example, Char (1983) found in her field study of classroom computer use that relatively regular access to computers allowed more students to use the software for longer periods of time as well as to take greater advantage of the software. In addition, she found that smaller class size enabled teachers to be more actively involved with students using the software.

4. Shared uses and the integration of discs into existing teaching and learning patterns may lead to using videodisc more as a teacher's tool than a student's tool--at least at the beginning. As a teacher's tool, videodisc is most likely to serve as a presentation medium for existing visuals and as a multimedia construction set. As a student's tool, videodisc is most likely to serve as a research resource and as a multimedia construction set.

Until a school attains enough videodisc equipment to permit the gathering of resources in a single location, or gives a single teacher regular and relatively concentrated use of a single machine, most in-class videodisc use may involve large-group use during lecture-demonstrations orchestrated by a teacher. In schools which enable access to the equipment outside of class, both students and teachers can create innovative visual presentations from existing material to be shown to whole classes. When used with whole classes under either teacher or student direction, videodisc is primarily a teaching tool used to impart knowledge. When access to equipment is less limited, videodisc appears to take on a second major role: a research

and development medium used by individuals and small groups without direct teacher supervision. As a learning tool, videodisc assists students' efforts at finding and creating understandings.

Thus, enhancing teaching may be the primary function of early videodisc use. Ideally, videodisc will offer easier and improved ways to teach and learn in tried-and-true ways at the same time that it supports and encourages truly innovative teaching and learning activities. In practice, however, because of constraints on access and adherence to conventional teaching and learning practices, videodisc may first support what teachers are already doing before it will lead teachers to change what they are doing, or enable students access to such a degree that it may profoundly affect their learning patterns. Videodisc as a tool for students may become more common only after teachers discover the features and benefits of the technology for themselves. As access and innovative teaching methods improve, more students may find new ways to discover and learn using interactive videodisc.

Suggested classroom use strategies.

Rather than furthering the status quo, we believe that videodisc can spur innovations in the educational process if its use occurs within the framework of new ideas about teaching with technology. The benefits may be realized on several different levels, from simply improving the quantity and quality of multimedia presentations in classrooms to empowering a student to create an original multimedia work by manipulating materials on an existing disc. (As video taping and editing equipment is more widely used in schools, students and teachers will also create their own discs.)

Research at the Educational Technology Center has emphasized the importance of using technology in teaching for understanding (Wilson, 1988). This approach to teaching with technology encourages analytical reasoning in which students take active roles in exploring problems and their teachers guide them to construct new knowledge and reach new understandings.

We believe that videodisc can promote understanding through active inquiry when it offers opportunities for teachers and students to choose, explore, and manipulate a wealth of visual presentations.

Our research indicates that these opportunities seem to be created most often when videodiscs are used in three ways.

1. Videodisc materials (disc images and related software text and graphics) serve as visual aids and catalysts.

When used by a teacher with an entire classroom of students, selected disc materials are used to present material for exploration, instruction, explanation, and discussion.

2. Videodisc materials serve as raw data for study.

Individuals and small groups of students investigate disc materials during periods of independent study in which they explore topics of interest, and find and make connections that are meaningful to them.

3. Videodisc materials serve as part of newly created presentations or other kinds of original multimedia constructions.

Using authoring systems, students and teachers create new multimedia works by reorganizing or repurposing existing materials.

Although many variations exist, these three primary uses take advantage of what videodisc does well, fit the most number of anticipated use patterns, and encourage practices that support active roles in teaching and learning. Because of existing traditions, we believe that in the near future the first use strategy will be primarily employed by teachers and the second will be primarily employed by students. The third strategy is already used by both students and teachers.

Designing for the Future.

Our three suggested uses outline a general design framework for school-based, level 3 videodiscs. Disc designs must support three purposes: presentational medium for teachers (and students); research resource for students (and teachers); and multimedia construction maker for both teachers and students. The first two functions can be seen as two ends of a continuum with authoring and editing capabilities mediating both and enabling the creation of multimedia works (some presentational in nature, others more for research and other uses) by teachers and students.

In general, the types of disc designs most amenable to our suggested uses offer flexibility in content and adaptability in format. In other words, subject matter is presented on many levels with the potential for near endless interconnections and a nearly infinite number of user-determined paths of exploration. Format is structured enough to enable users to identify organizing principles and thus navigate through or manipulate materials, but not so structured as to control the pace and path of interactions. Databases, for example, provide visual material in bite-sized pieces that can be readily manipulated to serve a variety of purposes in a range of settings.

Our research shows, however, that videodiscs designed for most classroom uses might balance open-ended design approaches with one or more structured approaches (e.g., storytelling) so that the needs of many teachers are met. We found that teachers often do not have adequate time or access to equipment to prepare original organizations of disc materials to support their lectures, and they often have their students use videodisc in small groups while the rest of the class is involved in another activity.

These conditions suggest that embedding a few packaged presentations--for use by teachers during whole class lessons or by students working independently--will make discs more useful in many classrooms. Such presentations need not be more than sample collections of images or sample routes through the images that serve as introductions to the subject matter--some may be organized by a thematic question or a specific problem. The

presentations will also serve as models of what teachers and students can create on their own, given sufficient time and access. Thus, the core of a model disc design might be a database, but some materials from the database might also be prepackaged.

Manipulating visual materials is facilitated by the advent of simple but powerful software that enables users to reorder and supplement videodisc content. For example, software such as HyperCard encourages students and teachers to design reports or presentations that are tailor-made to their classroom studies.

In addition to a disc and its related software, educational disc products should come with printed user support information. This information, teachers tell us, should include an index of all images, an outline of software content, sample lesson plans, activity sheets, and possible lecture scripts. These materials help instill confidence and provide guidance on how to teach with the technology, particularly for those teachers who lack school-wide support or peers with whom to share experiences.

New hardware configurations will also make using videodiscs easier and support the kinds of use strategies we recommend. For many teachers, logistical factors make videodisc impractical--they need advice on how to make the most of limited resources. Simplified hookups between players, computers, and monitors are also required. We favor large screen monitors and easy-to-use control devices. Equipment that must be shared should be made mobile by placing it on a cart.

We believe the most promising disc designs will allow teachers to retain two critical roles that they do best: guiding learning and assessing student performance. Such designs also encourage students to become knowledge detectives--users who actively pursue information and its meanings. The best disc designs enable teachers and students to maintain active and constructive roles in the teaching and learning process while exploiting the most interesting and creative potentials of the technology.

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